FORTYMILE RIVER:

Biological Aspects of Carrying Capacity

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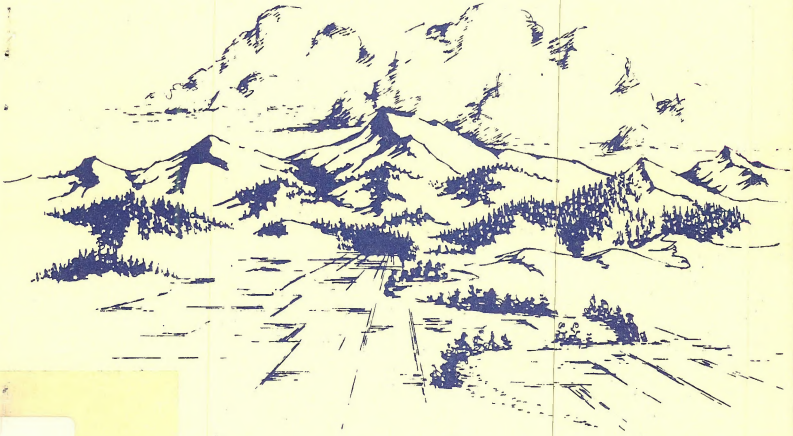

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Prepared for

Bureau of Land Management
Fortymile Resource Area
Tok, Alaska 99780

by

Michael R. Hudson
September 5, 1977

ABSTRACT

A trampling experiment was conducted on the Fortymile River to determine biological aspects of the river's carrying capacity. Four study plots were chosen based on incline, aspect, dominant vegetation, and proximity to areas of potential heavy visitor use. After ten visits in forty days, each study plot possessed a transect that had been trampled a total of 50, 250, and 1000 times. Degregation and sometimes recovery of dominant and most minor species were recorded. The annual production, percent cover of species in the trampled transects, the path width and the path's depth were noted at the termination of field work which was near the end of the growing season. A general outline and chronological sequence for carrying capacity research on a recreational river were proposed. Suggestions for additional research, specifically on the Fortymile River, are listed as well as a sequence of options for coping with a growing population of recreational floaters.

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INTRODUCTION

The Fortymile River in Alaska has been proposed for inclusion into our country's growing list of Wild and Scenic Rivers. In anticipation of that designation, information on biological aspects of the river's carrying capacity was obtained. With increasing recreational use of free flowing rivers, data on the current status of the Fortymile ecosystem is necessary, in order to monitor any change increasing recreational activity may precipitate. This study involved a section of the Fortymile drainage (Map #1), which is easily accessible by car. This area of the river currently receives the highest concentration of use, and thus, warranted primary consideration. As this area will logically receive the major influx of future visitors, controlled human tramplings were conducted on four separate and individually unique study plots (Bell, 1973; Dale, 1974; Wagar, 1964). The relationship between this type of impact, and the response of the various plant communities receiving the trampling, can be used to calculate permissable visitor population densities on the river, within the current management plan.

MATERIALS AND METHODS

Trampling studies were conducted on four sites (see Map #1) along a forty-one mile stretch of the Fortymile River and the South Fork of the Fortymile. Sites were chosen for their respective variety of aspect, moisture content, slope, vegetation types, exposure and proximity to currently used camping spots or historical areas. All plots were within a few yards of the Fortymile River (approximately 1500 feet in altitude). A Campways six man rubber raft and a Grumman 19 foot canoe were used for river travel.

Each of the four sites was outlined with surveyor's tape tied to stakes, and producing a 15 foot by approximately 12 foot rectangle (defined as a "plot"). Within this large perimeter, 4 smaller rectangles of 15 feet by approximately 3 feet were bordered by red surveyor's tape (defined as "subplot"). Each subplot was labeled with a tag to indicate the degree of impact they were to receive at each visit: yellow for 100 passes ("100"), white for 25 passes ("25"), blue for 5 passes ("5"), and red for the control (see Fig. #1).

Data sheets with entrees for date, time, weather, soil moisture and remarks were left on a protected clip board at each site (see Fig. #2). Weather was categorized as clear and sunny, party cloudy - less than 50% cloud cover, overcast - more than 50% cloud cover, drizzle - light rain, showers - heavy rain. Soil moisture was subjectively noted as wet, damp, dry and very dry. Number of people walking subplots, types of shoes, any disruption of subplots and last rain are a few of the comments included in the "notes" section of the data sheet.

The initial procedure upon arrival at a plot was to take color slides of each plot, and close-ups of their respective subplots, before beginning the trampling series. The actual trample consisted of a single walk of approximately 7 steps from one end of the subplot to the other. This is defined as one pass. The number of steps per pass and the weights of those trampling were not constant as those participating in the study varied from a 90 pound 15 year old to a 195 pound college student. The type of footwear included vibram soled boots, rubber hip waders, tennis shoes, wet suit booties, moccasins and bare feet.

Upon completion of each subplot's impact, a series of "post" color slides were taken. Immediate response of the subplots vegetation was noted. Those species considered fragile and those apparently resistent were recorded. A sample of all vegetation on all subplots was collected in self-adhesive acetate (Christenson, 1975) and returned to the Fortymile Resource Area headquarters for positive identification.

The procedure after the initial trample varied slightly. Notes and "pre" photographs were taken immediately upon arrival at a site, to evaluate the degree of rehabilitation that occured between visits.

Each pass was made over the same area in each subplot. The trampling sequence continued from June 29 to August 6, 1977, and consisted of 10 visits to each site. Thus, the most heavily impacted subplot at each site received 1000 passes, the moderately impacted subplot received 250 passes, and the least impacted subplot received a total of 50 passes. The interim of recovery, that time elapsing between 2 visits to a plot, varied from 8 days to 12 hours.

FIRE PIT

Adjacent to the first plot at Napoleon Creek was a fire ring that had been produced July 7, 1977. The initial destruction and subsequent reinvasion of ground cover was monitored by photographs and field notes.

TENT SIMULATION

A simulated tent site, represented by a doubled over 12 foot by 3 foot section of tarp, was set near the third plot. The changes occurring below and beside this tarp were monitored by photograph and written records.

WATER LEVELS

On the South Fork side of the confluence was located a series of water indicators. This consisted of a stake driven into the rivers current high water mark and then supported by rocks. The stakes were located on a transect of nearly uniform incline. The distance between each stake was measured and the change in river level was extrapolated from a scale graph.

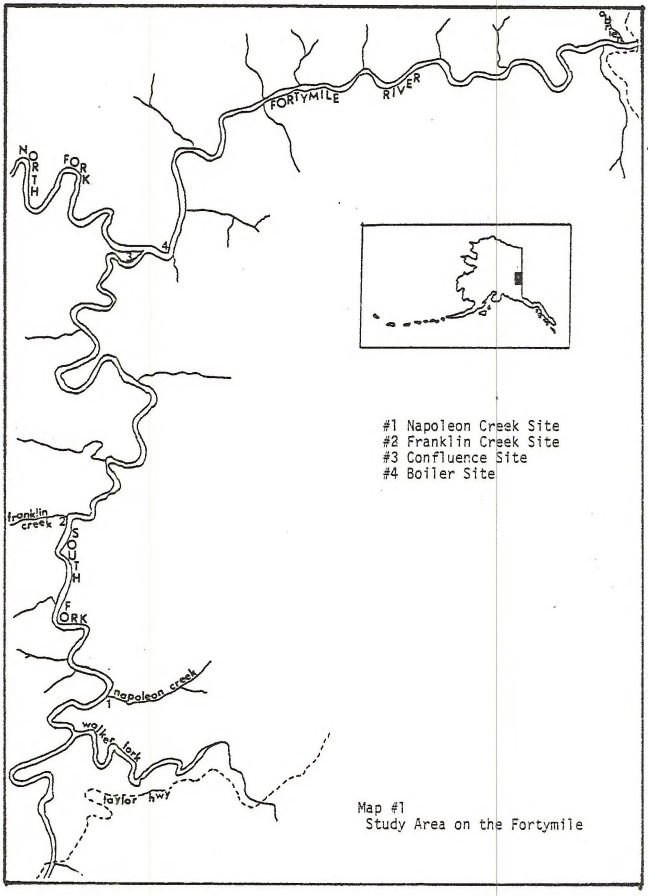
EVALUATION OF TRAMPLING SERIES

Upon completion of the trampling series, percent cover within each subplot was determined. A 5 foot section of a tape measure was layed over a central section of each subplot's path. The type of vegetation, and the sum of the distance each type of plant covered under that 5 foot line was recorded.

Immediately following the determination of percent cover, samples were collected for annual production measurements. Surface vegetation was removed from each trampled path within a 10cm by 50cm rectangle. These 10 by 50 plots were all directly on the worn path, and parallel

to other subplot samples taken in the same plot. The collected plant matter was stored in plastic bags, and then marked with colored tags indicating date, plot and subplot. The samples were dried at the University of Alaska's Institute of Arctic Research in the same drying oven, at 65°C for 2 and a half days. Each sample was then weighed on a Mettler P1200 balance and the weights recorded to the nearest 0.01.

Slides for visual assistance in evaluating trampling impact have been categorized according to visit, date, plot and subplot. These slides and a legend are on file at the Fortymile Resource Area's office near Tanacross. The photographs can be of future use if any studies on recovery rate are to be conducted during the next growing season.



Map #1
Study Area on the Fortymile

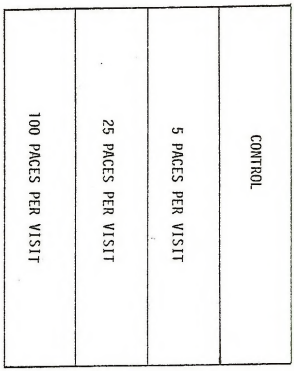


Fig.1 Diagram of Study Plot and Subplots.

DATE	TIME	WEATHER	SOIL DAMPNESS	NOTES

Fig.2 Facsimile of Plot's Data Sheet

RESULTS

NAPOLEON SITE

Plot Summary

Napoleon Creek is located 7 miles downriver (see Map #1) from the South Fork Bridge, mile post 75 on the Taylor Highway. The plot is situated on the right limit of the Fortymile River, just upriver from the mouth of Napoleon Creek. The area was chosen because of its pristine appearance, northern exposure, and tundra-like abundance of moss and lichen (Note: the genus and species of all flora and fauna mentioned in this paper are included in Appendix II, along with their common name(s). Labrador Tea, the predominant flowering species, and grasses were found throughout the plot, while young spruce and willows, bearberry, lupine and blueberry were found in varying quantities from one subplot to another. The plot location had an untouched look (moss up to 8 inches thick), with only a few game trails above and below the sites perimeter. All plots contained a definite incline (average 26 inches), while the 100 passes and the 25 passes subplot also had a step-like terrain (see Fig. #3). This uneven topography led to uneven damage from trampling.

Numerous miners make Napoleon their temporary place of business, and none knew the location of the plot until it was pointed out. Napoleon Creek was actively mined in the early days of Fortymile gold activity, and even this summer its mouth was the site of a small gold strike. A family mines a claim year-round, one-quarter of a mile up the creek; and a cabin across from the mouth has been inhabited periodically during both the summer and the winter.

For its history, gold and convenient location down-river from the BLM canoe landing, the Napoleon Creek area can be expected to be visited with increasing frequency, in future summer seasons. The plot, therefore, is in an area where impact can be expected to be high, while its current condition can be considered untouched. The aspect does not lend itself to camping, but rather to intransit impact. The result of trampling this plot could be applied to other areas of similar characteristics, as yet little visited by man.

Napoleon Trampling

The Napoleon plot was set up on June 22 and first trampled June 29. After this first walk, the 100X subplot was already obviously affected. The path was readily visible, and the slope of the step-like inclines already had moss and lichen uprooted, exposing the underlying soil. The trail was only faintly visible at the 25X subplot and even less so at the 5X.

The site was revisited July 3, and trails were still discernable on all

3 subplots that had been trampled. By the July 7 walk (3rd trample), the 100X hillocks showed obviously increasing damage, with roots being exposed where feet were consistently placed while climbing the subplot. The dead vegetation (mainly moss) had given the path very definite borders, and also helped to stabilize future damage. The 25X hillocks also began to show the same effects of repeated climbing, while the 5X trail was still faint.

By the 5th trip (July 18) a pattern had developed. The 100X subplot, with 500 passes now, had no living lichen and very little living moss. Most of these organisms were dying or already pulverized. The path was obviously lower than the surroundings and wider than the 25X. The 25X was a smaller version of the 100X.

Neither showed signs of recovery, and even evergreens in the path had skinned bark and broken twigs. Labrador Tea appeared to be the hardiest species as it remained on the periphery of the path and was making occasional inroads onto the trail with new growth. The 5X had the appearance of the game paths nearby. The trail was unobtrusive, winding and had all the plant species still present. A depression was observable, but the downed grass, moss, and lichen still retained their natural color, rather than the brown straight swaths exemplified by the two heavier traveled subplots.

By the 7th walk the 5X began to have a more permanent appearance, although it was the only subplot where lichen still was not totally crushed. The 100X and the 25X now, not only had nothing living, but developed a churned look. The 25X had the same severe damage on the hillock incline as the 100X but was still resilient and spongy in sections where the 100X did not give.

By 10 visits all paths had an observable impact. The 25X and the 100X subplots seemed identical in type of damage sustained and varied only in degree. The 5X subplot had obvious damage, but it did not give the appearance of irreversibility, as did the other plots.

The 25X and the 100X paths dried faster in clear weather, and were more moist in damp conditions, than the control and 5X. Insects were visibly swarming over the two former subplots and not over the 5X or control. The most severe damage was found on the small steep hill on the 100X subplot. Not only was there nothing living here, but the debris had been removed leaving raw earth. This earth was cold to the touch only a few centimeters below the surface, suggesting a permafrost layer very near the surface.

The removal of covering debris also seemed to initiate another increase in damage from what had been a plateau of impact. A definite groove in the soil was forming on the incline. The steep section of the 25X subplot had severe damage, with dirt and slick roots exposed, but the damage was less severe, and the rise not as steep as the 100X.

The 100X had the widest (see Table III), deepest (see Table IV), straightest, and brownest path of wear; and the clearest borders with the surrounding untrampled vegetation.

These parameters decreased in magnitude with decreasing impact. 100X and 25X paths consisted of dirt, dead moss or grass, and upturned roots. Recovery of moss, grass, and especially Labrador Tea was noted in the 5X and 25X paths, but very little if any on the 100X. The woody plants, spruce and willows, were easily uprooted, even on the 5X. This observation could be related to the nearness of the permafrost layer.

The variety of species and percent cover (see Table IIa) on the subplot paths decreased from control to the heaviest impacted trail. Labrador Tea demonstrated the ability to withstand, recover and invade a trampled section. Grasses were quickly bent, damaged and crushed, but also came back the fastest between site visits. Lichen and then moss were the most fragile. Moss persisted in protected areas on the path, but the lichen showed no ability to withstand or recover from an initial trample.

Annual production (see Table I, Fig. 8) in the 100X resulted almost solely of barren stalks or moss remnants. The luxurient growth on the 5X plot had the greatest amount of vegetation after drying. Green growth was found on this path almost 8 inches below the path. The control also had heavy growth of moss and lichen over all of the subplot, but the moss layer at the site of sampling was not as deep as the 5X. Growth was most uniform, subplot to subplot at Napoleon, than at any of the other 3 sites.

Fire Pit

No measurable or observable change was noted for the entire period of observation. Circumference of burned material remained constant, with no invasion of ground cover vegetation.

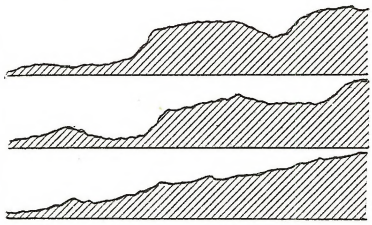
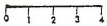


Fig.3 Napoleon Plot Profile



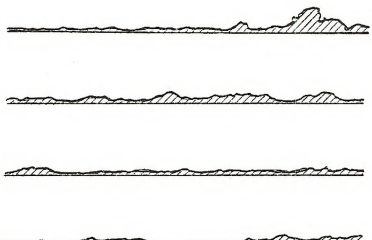
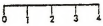


Fig.4 Franklin Plot Profile



FRANKLIN SITE

Plot Summary

Franklin Creek is located 12 miles downriver from the BLM canoe landing, located near the South Fork Bridge, mile post 75 on the Taylor Highway. The study plot is located on the right limit of Franklin Creek approximately 35 yards from the high water mark of the Fortymile River.

Franklin Creek was involved in Fortymile history from the inception of gold activity in this section of Interior Alaska. The remains of the town of Franklin, a blacksmith shop, a tramway across the river, mining equipment, and isolated cabins up the creek all hold the visitors interest. Evidence of extensive land movement by heavy equipment and drift mining are very much in evidence. The mouth of the stream, the stream itself, and the gravel bar extending into the Fortymile all have evidence of current mining activity. Gold, readily available in small amounts, attracts visitors both via river and the overland route from the town of Chicken. The prospect for an increase in visitors is even greater here than for the Napoleon area.

The plot itself was laid out on old tailings that have developed good regenerative ground cover. Stakes for site delineation had to be held in place by rock reinforcement, as little top soil had accumulated. The date of the tailing deposition is unknown, so vegetative response to this study's controlled disruption could be of assistance in future site and campground management.

A heavily used camping area was located only a short distance to the southeast, and campers commonly set up their tents just across the creek, on a set of parallel tailings during the course of this study. Along with the river running visitors at Franklin, one couple had set up a relatively permanent residence in the old school house, and 4 other groups spent up to one week in less hospitable cabins, or in impromptu campsites. Extensive trampling, destruction of hardwoods for fire, and other ecological alterations were quite obvious during the 45 days of field work.

The plot was situated on rocky soil, level aspect (see Fig. #4), and adjacent to both gold workings and a trail to additional workings further up the creek. The site had obviously been influenced by man, and was making a hardy comeback. It exhibited a wide range of those types of species commonly found in gravelly environments near streams. Willows up to 6 feet, grass and low broad leaved forbs were the predominant species of plants, along with lower concentrations of arctic poppy, wild sweet pea, lupine and blue bells. Very near, but not within the borders of the plot, were found numerous wild roses. The water level of Franklin Creek was only 1 and a half feet below the study plot, and thus it is possible that the subplots may be under water during

the spring. Due to the high visibility of the site, the relatively dense population and the presence of many dogs, unmonitored impacts may have occurred on trampled and control subplots. This study plot did exhibit a slight continuum of vegetation types rather than the uniform densities seen at Napoleon.

The control was originally more barren with a high incidence of grasses and flowering plants, and fewer, smaller woody plants. At the opposite end of the plot, the 100X possessed more willows and low lying forbs. Each subplot had a number of rocky sections, but for the most part could be walked comfortably. The 100X did have a concentration of rocks requiring a step over, or a step up, thus tending to concentrate impact just before and just after the rocks.

Franklin Trampling

The Franklin plot was set up June 27 and first impacted June 29. Obvious damage was immediately apparent while still walking the 100X subplot for the first time. Low lying vegetation in the path was crushed and seemed beyond regeneration, while woody plants had stem damage. The 25X subplot had some soil exposed and disrupted, while the 5X had only bent and not crushed ground cover.

The plot was revisited July 4 for the second trampling series, and no regeneration of the 100X subplot was noted. The vegetation crushed 6 days before was dead or dying in the path. The 25X showed signs of recovery and the 5X subplot had no evidence of disruption. By the end of the second walk, the soft broad leaf forbs in the 100X path were reduced to pulp. The small willows showed good resistance, but were damaged at the boot level. Some grass was crushed and mangled, especially just before the rock accumulation, where one was forced to consistently walk on the same spot. Grass in other areas on the path was still upright and healthy. The 25X subplot had no crushed vegetation, only bent, and the woody plants exhibited no damage. The 5X had only the slightest evidence of a trail.

By the seventh of July the 100X subplot, now with 300 passes, was obviously the most severely affected path in the entire study. Damp vegetation from a recent rain significantly increased the rate and amount of damage, so that considerable amounts of underlying soil and sand were upturned. All types of vegetation experienced damage, with living grasses and forbs now quite absent from the path. The damage to the 25X subplot produced a definite path, but not near the severity of the 100X. The 5X had damage to grass, but not much more than that seen in the control. No trail was visible.

From the third trample on, there was little change in the plots. All vegetation on the 100X path was dead, and most was decomposed due to grinding action between the rocky soil and the sole of the boot.

Because of that rocky soil, no great depth was produced on the trampled tract, and no significant increase in trail depth was seen after the first three visits. Accumulated debris, together with mud and sandy footprint depressions near the rocks on the end of the 100X plot, gave some unreasonably high (e.g.3 inches) trail depth (see Table IV), and the average of 0.8 inches may be slightly misleading.

No difference in depth between path and neighboring vegetation could be measured in the 25X and the 5X subplots. Widths of trampled trails (see Table III) were of the same order of magnitude as at Napoleon. Lack of any significant trail depth at Franklin compounded the problem of deciphering where the trail stopped, and where unaffected vegetation started on the 25X and 9.0 for the 5X are probably an overestimation. The 5X width was particularly difficult to measure, as it was a meandering area of downed grass, that was still green and healthy. No earth was exposed and no damage was observed to the woody plants. The trail appeared much narrower to the eye than indicated by the figures in the table.

This subplot was obscured by waist high willow overgrowth from the sides of the path, thus reducing visual impact. When the willows were moved aside, definite browned area of dead vegetation, raw rock and sand were exposed. However, contrary to the 100X subplot, some forbs, grass, and moss persisted throughout the study, and made inroads of new growth. The 25X and the 100X, to some degree, had moss growing that was protected from trampling by growing between rocks or in rock cracks.

The percent cover (see Table IIB), and annual production of the 100X subplot (see Table I, Fig. 9), was made up completely of dead, but not pulped grasses. The number of species and annual production increased for the 25X. The same trend was found for the 5X and control. The woody plants were the most durable of all species in this plot. It should be noted that some willows were in the path, but none were taken in the 50 by 10cm annual production sample. Grass was again both one of the more fragile plants, but also one of the most successful in recovery and peripheral encroachment.

CONFLUENCE SITE

Confluence Summary

The confluence of the North and South Forks of the Fortymile River, is 24 miles downstream from the South Fork canoe landing. The study plot is located in an area already developed by BLM as a campsite. A series of steps to the campsite have been built from the high water mark, to a bluff overlooking both Forks. The stairs are easily accessible on the left limit of the South Fork, and the right limit of the North Fork. The campsite has a number of clearings in the hardwood and spruce stands for tents, as well as a fire pit with 2 grills, and a primitive pit toilet. Although there are no relics from the early mining days, the convenience of the spot, its scenery, and its presently developed state explain the heavy use noticed this summer, and indicates no reason why this use should not increase.

The study plot overlooks the South Fork on a high, relatively flat (See Fig. 7) bench. The plot is within 15 feet of the fire pit, and in close proximity to both the other tent sites and the outhouse, suggesting that the area has had previous use as a tent site. However, any recent or historical use has had little effect on the natural setting. As with the Franklin site, the Confluence plot did not have a uniform distribution of plant species from subplot to subplot. The control, 25X, and 5X were more open to the sun and contained a high concentration of grass, yarrow, and forbs which together with moss and wild rose created a rick cover of vegetation, second only to the tundralike appearance of the Napoleon plot. The 100X, and the control to a lesser extent, were situated near a stand of tall white spruce resulting in greater overstory, and consequently, wild rose, lichen, and moss were the dominant species of plant. The 100X and control also possessed a much lower concentration of yarrow and grass. These two subplots did not have the dense appearance of the 5X and 25X, exhibiting instead, numerous barren spots covered with pine needles or shallow moss.

Confluence Trample

The Confluence plot was set up June 28 and the first trample was June 30. The 5X subplot possessed a barely discerable path, and the 25X had a broader and more obvious trail, but had the appearance of easily overcoming the impact and recovering. Grass was bent but very little was bruised. The 100X not only had bent grass, but most vegetation in the developing trail was bruised and crushed, with much of the moss turned up, exposing soil.

The second visit, on July 4, showed the 5X subplot completely recovered and the 25X path improving. The 100X subplot showed some grass recovery, if closely inspected, but the visual damage was obvious and of permanent appearance. By the end of the second walk, the 100X path was noteworthy because of its broad appearance, amount of dirty turned up, and

destruction of grass. The 25X had some bruised and flattened grass, but still lacked the appearance of irreversible impact. The 5X, with now 10 passes, had a path visibly only to one who was looking for a trail.

By the third visit the 5X subplot was still only lightly exhibiting the impacts of trampling, but the 25X had all soft vegetation down, bent and crushed with only the hardier woody species upright. Nothing on the 100X trail was standing, and the path had the well worn, pine needle paved appearance, of many permanent trails in an evergreen forest. Both Franklin and the confluence were visited on this day, and both were walked in the rain. Franklin had a much more severe response to trampling in the rain that the Confluence did. A cycle of warm days, followed by rain, followed by warm sunny days again, had a definite rejuvenative effect at the Confluence. It was noted that yarrow was coming up both at the edges of the trail, and on the trampled path itself.

This re-establishment of green vegetation was noted on the 100X subplot July 14 (4th trample), and confirmed on numerous sections of the same subplot during the 6th trample (July 22). Although the 100X path was five inches broader than the corresponding subplots at Napoleon and Franklin, the Confluence was the only site where significant regeneration occurred with such heavy impact. Yarrow, forbs, and spruce seedlings were recorded as sprouting on the trampled path. The 25X was definitely narrower than the 100X, and also showed rejuvenation of forbs, rose, sprouting yarrow, and healthy moss. A major difference in appearance was the abundance of dead grass in the 25X, but this is probably due to less grass originally in the 100X subplot. The initial lack of grass in the 100X subplot may be one explanation for the excessive width of this heavily trampled path. The 5X path was now clearly visible, but of a wandering nature with uncertain borders and infringement by numerous plant species. Most plot species were represented in the 5X path, and it was only the dead grass that was responsible for the trail's visibility. The continuing sunny weather ultimately had a negative effect on the 100X subplot.

During the 8th trample (July 28) the 100X trail had a cracked earth aspect, that soon changed to dust at the completion of the walk. All other subplots retained some semblance of a natural state, exhibiting no cracked earth or dust. After the trample, no accurately measurable change in the substrate depth (see Table IV) could be recorded for any subplot. Trail width (see Table III) was of a wide variance (31 inches to 16 inches) on the 100X plot, reflecting the successful growth of yarrow on trampled areas, and lack of limiting grass growth. The 100X trail consisted mainly of dead vegetation, fallen spruce needles, exposed soil, and roots. The 25X path was more defined than the 100X, due to the grass on the edges, and had little variance in width measurements. The leg brushed against vegetation in this plot, whereas such was not the case with the 100X. Some variety of living plants endured the trampling,

and the plot appeared to have a much greater possibility of rapid recovery, than the severely affected 100X trail. The trail width in the 5X may be a liberal figure. At points, the measurement of width was difficult, as sparse vegetation, coupled with minimal damage from trampling, gave a uniform appearance to that whole section of the subplot. Annual production (see Table I, Fig. 11) samples demonstrated that the 25X path possessed the greatest amount of plant matter. Such a discontinuous distribution of plant matter, could explain the confusing group of figures.

Water Levels

Figure 14 demonstrates the unpredictable nature of water flow in the South Fork. June 28 was taken as the base line for this study and ultimately became the high water mark for the duration of this study's field work. A steady drop occurred until July 15, when a very large drop (15 inches) was recorded. Within 5 days (July 20) an even larger rise (approximately 17 inches) took place. On the 22nd of July, a further increase occurred and then the drops were comparatively precipitous until August 8, the culmination of the water study. The Fortymile is dependent on its rainfall for its flow, and thus the depth of the river reflects the quantity of the previous day's precipitation. Flash floods and very rapid changes in the level of the Fortymile have previously been recorded (Price, 1925).

Tarp Site

This simulated tent site was broken down August 6, 41 days after the tarp was set in place. The tarp was located between the outhouse and the confluence plot, in an area with dense tall grass. That grass was immediately flattened by walking over the insite tarp a number of times. The tarp was not walked on, or lifted again, Jutil June 22 when a photograph and notes were taken. At that time the grass bordering the tarp was 2 feet deep in height and lush. Under the tarp was brown and yellowing grass, but with some blades still green. On August 5 the tarp was permanently removed, and there was no appreciable change in vegetation since the June 22 observation.

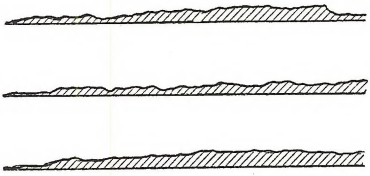


Fig.7 Confluence Plot Profile

0 1 2 3 4 Scale in Feet

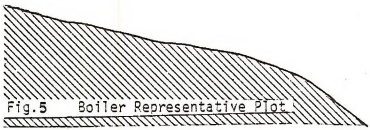


Fig.5 Boiler Representative Plot

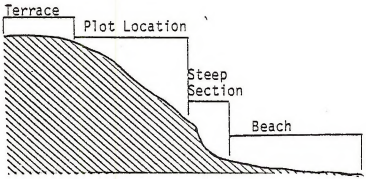


Fig.6 Boiler Site: Orientation of Plot Location in respect to the Immediate environment.

0 1 2 3 4 Scale in Feet

BOILER SITE

Boiler Summary

The remains of an old boiler are located on a bench, just around the bend from the confluence of the North and South Forks of the Fortymile. This is approximately 25 miles from the BLM canoe landing, at mile post 75 on the Taylor Highway. The boiler is hidden from the river, but a well worn path, on the left limit of the Fortymile, leads from a gravel and sand beach directly to the massive relic. The sandy beach, above the gravel and high water mark, has been used by floaters numerous times, but has not been improved by the BLM. Activities such as fishing, viewing artifacts, swimming, berry picking, and rock climbing were observed. Creek water, adequate wood supply, a fire pit, and good location for tents were all present. Many people floating the river commented on the scenery, and the desirability to stay a night or number of days in this location. The boiler area has great potential as a primary choice for a floater's stop, or as an overfill selection if the hardened and improved confluence campsite is at capacity.

The camping area itself is on sandy substrata, and, thus, eliminates any biological destruction from tent placement, or movement from tent to fire to river craft. The berry fields, cabin, cache, sled, and boiler are located up a steep embankment, and a well worn trail from the camping area up the embankment to the bench, attests to the effect of present visitor use. The boiler study plot was arranged parallel to this trail.

It was hoped to qualify the amount of damage, or tramplings on the study plot, by producing a path of similar appearance to the natural trail. Such a comparison would be of assistance in relating simulated use by trampling studies to actual visitor impact occurring on the Fortymile. It was also desired to establish information on trampling impact to a typical river embankment, an incline quite different from the Napoleon slope's vegetation (see Figs. 5 & 6).

The boiler plot is east facing and has good drainage. A stand of hardwoods provide overstory, and the plot had a carpet of fallen birch leaves. Again, vegetation types in the plot were not consistent from the 100X to the control. The control had a thick and tangled carpet of Labrador tea, wild rose, and grass on the upper section, changing to predominantly mare's tail and rose on the lower section. Bearberry, moss, and forbs were also present. The 100X plot lacked the thick grass and mare's tail growth, and substituted thinner ground cover of rose, bearberry and forbs. All subplots possessed the same general topography as demonstrated in Figure 5.

Boiler Trample

This plot was arranged June 30, and first walked the same day. The 100X demonstrated the greatest damage in this plot, but the impact was the least for all the study's 100X subplots after only 100 passes. The plot

is unique in that dead birch leaves, once covered by ground vegetation, are exposed by trampling, thus exacerbating visual impact. This characteristic was first noted after the second set of trampling (July 5) in both the 100X and 25X subplots. The 5X demonstrated some bent grass, but a trail was essentially nonexistent. The bent and downed grass was present to a greater extent on the 25X, and together with the exposed birch leaves presented a definite trail. The 100X showed the greatest impact on the lower section, where the trail became noticeably steeper.

By July 7, and the 3rd series of passes, the experimental 100X had little vegetation, and was a trail of marked similarity to the naturally produced path to the boiler. Width, presence of dead birch leaves, and the location of the most seriously affected sections, corresponding to the steepest sections, were all parameters of similarity. The 25X exhibited more damage at the lower, steeper end, as well as leaf destruction to the Labrador tea. One week later, just before the fourth trample, the 100X still appeared barren and flat, but closer inspection revealed some bearberry and moss had had adequate time to make some recovery. The 25X subplot had a noticeable trail, especially on the lower section which was without vegetation, and covered with leaves. The upper section was not so reminiscent of the 100X path, and possessed some healthy growth of moss and Labrador tea. The 5X had only a linear area of downed grass to indicate trampling. Rose and Labrador tea were still thick on the section walked.

After the 4th walk the 100X showed the greatest change with dirt being dug up on the steep section exposing large roots, and developing a berm of accumulated dead leaves, crushed vegetation, and dirt. This type of damage continued, and ultimately the sections of each subplot, most effected by trampling were the lower steep sections. The 100X steep section actually became dangerous in wet weather with exposed slick roots. As a consequence, the 100X path broadened at its base, developed definite depressions for toe holds, and readily formed mud with slight precipitation. Such severe changes were not noted in the 25X and 5X subplots.

At the culmination of the study, the wild rose on the periphery of the 100X path lessened the visual effect of trampling, by growing up and over the edges of the trail. Bearberry was also recovering along the limits of the trail, and, thus, obscured the once definite borders of the path. Even with this mitigation, the boiler's 100X path was the widest (see Table III) by over two inches. This width, along with almost total destruction of vegetation (see Table I), slope of the subplot, and definite depression at the path below the level of the top soil (see Table IV), would seem to presage future extensive damage in the spring. The 25X subplot is much more vegetated, narrower, and more distinctly bordered than the 100X. Characteristics of the 100X subplot, development of toe holds, exposure of roots, accumulation of a debris, berm and depressions of top soil, also occurred here, but to a much lesser degree. Walking was possible without slipping, grass, bearberry,

and tea were present in the path itself, as well as small concentrations of blueberry, rose, and forbs (see Table IIc). The 5X had quite a gradient of trampling effect. In the upper section downed grass was still the only indicator of trampling. The elimination of the grass, exposing a preponderance of underlying Labrador tea, was a clear marker of the trampled path. Labrador tea was remarkedly resistent to trampling. This plant was still present in a tangled green mass of twigs and leaves in the 5X path, and present as twigs and a few healthy leaves in the 25X. The lower section of the 5X subplot was definitely a well worn path, with little vegetation present on the steep section. Keeping with the general trend for all subplots, the variety of species (see Table IIb) on the trampled plot decreased, with increasing impact.

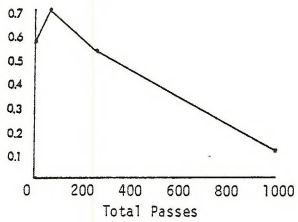


Fig.8 Napoleon Site: Annual Production in Relation to Total Passes

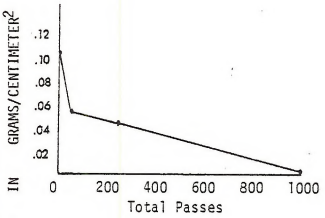


Fig.9 Franklin Site: Annual Production in relation to Total Passes.

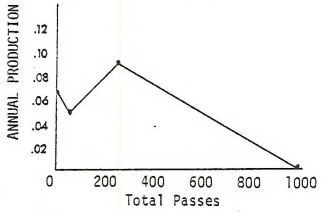


Fig.11 Confluence Site: Annual Production in Relation to Total Passes

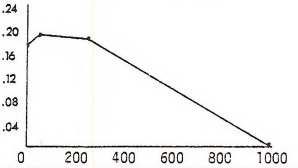


Fig.12 Boiler Site: Annual Production in Relation to Total Passes

TABLE I

Annual Production: Total Mass, Grams per Square Centimeter and Percent of Maximum Mass Collected From a 10 by 50 Centimeter Quadrant of Each Transect After 10 visits.

	Total Mass	Gm/Cm^2	Percent Max.
Napoleon			
1000 Passes	55.33grams	0.111	15.80%
250 Passes	271.51	0.543	77.50
50 Passes	350.10	0.700	100.00
Control	280.64	0.561	80.15
Franklin			
1000 Passes	4.32grams	0.009	7.94%
250 Passes	24.85	0.049	45.65
50 Passes	26.62	0.053	48.90
Control	54.43	0.108	100.00
Confluence			
1000 Passes	2.03grams	0.004	4.63%
250 Passes	43.82	0.087	100.00
50 Passes	25.60	0.051	58.42
Control	34.40	0.067	79.22
Boiler			
1000 Passes	0.00grams	0.000	0.00%
250 Passes	94.17	0.188	99.36
50 Passes	94.77	0.189	100.00
Control	82.55	0.165	87.69

TABLE IIa

Percent Cover and Vegetation Type Determined Over a Five Foot Transect Immediately Following the Trampling Period.

Site	# Passes	Vegetation Type	# Inches	% Cover
Napoleon	1000	Sphagnum sp. Elymus sp.	2	3.33%
	250	Sphagnum sp. Elymus sp. Arctostaphulus uva-ursi Picea mariana	5	8.33
	50	Spagnum sp.	5	8.33
		Arctostaphulus uva-ursi	1	1.66
		Picea mariana	5	8.33
		Ledum groenlandium	1	1.66
		Cladonia sp.	8	13.33
	Control	Sphagnum sp.	21	35.00
		Elymus sp.	19	31.66
		Arctostaphylus uva-ursi	22	36.66
		Ledum groenlandium	31	51.66
		Cladonia sp.	50	83.33
		Lupinus arcticus	7	11.66
		Vaccinium uliginwsum	2	3.33

TABLE IIb

Percent Cover and vegetation Type Determined Over a Five Foot Transect, Immediately Following theTrampling Period.

Site	# Passes	Vegetation Type	# inches	% Cover
Franklin	1000	Elymus sp.	22	36.66%
	250	Spagnum sp.	15	25.00
		Elymus sp.	34	56.67
		Misc. Forbs	9	15.00
	50	Spagnum sp.	16	26.67
		Elymus sp.	38	63.33
		Misc. Forbs	7	11.66
	Control	Sphagnum sp.	24	40.00
		Elymus sp.	36	60.00
		Salix sp.	19	31.67
		Misc. Forbs	10	16.67
Confluence	1000	Sphagnum	3	5.00
		Achilla millefolium	5	8.33
	250	Sphagnum sp.	8	13.33
		Elymus sp.	45	75.00
		Achilla millefolium	13	21.67
		Rosa acicularis	2	3.33
		Misc. Forbs	7	11.67
	50	Spahanum sp.	16	26.67
		Elymus sp.	45	75.00
		Rosa acicularis	4	6.67
		Misc. Forbes	25	41.67
	Control	Sphagnum sp.	28	46.67
		Elymus sp.	14	23.33
		Achilla millefolium	14	23.33
		Rosa acicularis	8	13.33
		Salix sp.	6	10.00
		Cladonia sp.	23	38.33
		Haloragidaceae vulgaris	6	10.00

TABLE IIc

Percent Cover and Vegetation Type Determined Over a Five Foot Transect, Immediately Following the Trampling Period.

Site	# Passes	Vegetation Type	# Inches	% Cover
Boiler	1000	Sphagnum sp.	3	5.00%
		Rosa Acicularis	1	1.67
	250	Sphagnum sp.	2	3.33
		Elymus sp.	19	31.67
		Ledum groenlandicum	3	5.00
		Arctostaphylus ura-ursi	19	31.67
		Vaccinium uliginosum	1	1.67
	50	Spagnum sp.	4	6.67
		Elymus sp.	60	100.00
		Ledum groenlandicum	30	50.00
		Arctostaphylus ura-ursi	12	20.00
	Control	Sphagnum sp.	10	16.67
		Elymus	12	20.00
		Ledum groenlandicum	45	75.00
		Arctostaphylus ura-ursi	28	46.67
		Rosa acicularis	2	3.33
		Haloragidaceae vulgaris	25	41.67
		Misc. Forbs	3	5.00

TABLE III

Comparative Path Widths in Trampled Transits After Ten Visits.
Measured in Inches.

	Ten Samples	Average
Napoleon		
1000 Passes	17,17,16,14,16,16,15,16,16,13	15.6in.
250 Passes	10, 8, 8, 8,12, 9,10, 9,11, 9	9.4
50 Passes	5, 4, 8, 7, 7,10, 9, 8, 7, 7	7.2
Franklin		
1000 Passes	13,12,16,13,14,16,18,22,15,14	15.3in.
250 Passes	10, 9, 9,10, 9,10,10,11, 7, 9	9.4
50 Passes	9, 8,12, 7, 7, 8, 9, 9,10,11	9.0
Confluence		
1000 Passes	23,22,23,21,21,17,18,20,23,21	20.9in.
250 Passes	15,13,14,12,13,12,12,14,15,13	13.3
50 Passes	13, 8,10, 9,13,13,12,12,12, 8	11.0
Boiler		
1000 Passes	20,21,19,19,18,21,24,27,31,32	23.2in.
250 Passes	18,14,13,12,13,14,15,14,16,15	14.4
50 Passes	8, 7, 8, 8, 9,10,11,11, 8, 9	8.9

TABLE IV

Comparative Path Depths in Trampled Transects After Ten Visits. Measured in Inches.

	Ten Samples	Average
Napoleon		
1000 Passes	4,4,5,2,3,2,4,5,6,6	4.1in.
250 Passes	6,4,3,2,1,3,1,2.1,3	2.8
50 Passes	0,4,2,1,5,0,3,0,3,1	1.9
Franklin		
1000 Passes	1,0,3,0,1,0,1,0,2,1	0.8in.
250 Passes	Insignificant	0.0
50 Passes	Insignificant	0.0
Boiler		
1000 Passes	4,2,0.5,1,1,0,1,0,1,1	1.1in.
250 Passes	3,1, 0,0,0,0,0,1,1,0	0.6
50 Passes	Insignificant	0.0
Confluence		
1000 Passes	Insignificant	0.0in.
250 Passes	Insignificant	0.0
50 Passes	Insignificant	0.0

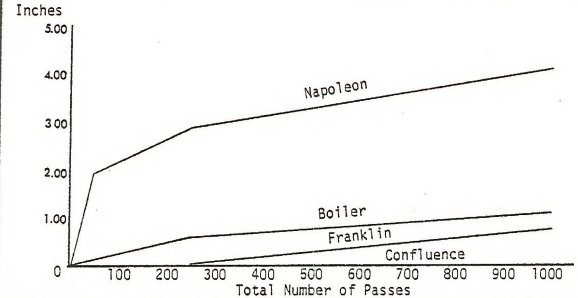


Fig.13 Comparative Path Depths on Trampled Transects After Ten Visits

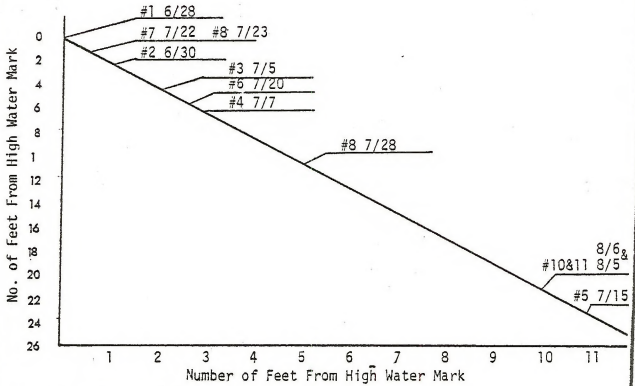


Fig.14 Approximation of Water Levels at the Confluence Site from 6/28/77 to 8/6/77.

DISCUSSION

The major problem with simulation studies is their conversion to practical application and actual conditions. In a period of 40 days the respective subplots were impacted, 50, 250, and 1000 times. If a camping area was visited by a party of two, twice a week for 40 days, a total of 336 passes along an identical path might be experienced. This is considering both individuals making two round trips apiece hauling gear, first to the campsite, and then hauling gear back to the raft or canoe. Another three more trips apiece over that same path, could conservatively be considered for fishing, washing, gold panning, or merely for after meal exercise. This roughly corresponds to the moderately trampled study subplot of 250 total passes.

Estimations of party size and number of visits per week to a site are based on personal observations and information volunteered from permanent residents of the river. Using this 250 figure as an average, it would seem that plant destruction, measured in annual production, to the various vegetative microsystems investigated along the river, varies from near zero to 45% (see Table I), when compared to a control in the immediated vicinity. These figures are for a 40 day period over one season only.

Again using annual production as a measure of degregation, a rocky bank of previously impacted substrate, i.e., Franklin, would affect the greatest by walking visitors. A well drained embankment, such as at the boiler, would be most resistent to this level of impact. However, a well drained embankment would also present a serious visual impact due to trail depth, and especially wide trail width. The boiler site, with its good drainage, had the widest, and the second deepest path of the 250 subplots. The boiler also had the least reduction in annual production. To summarize, such an environment would present serious visual impact, but in reality would be the least biologically impacted. The natural trail leading to the boiler is clearly visible from the river, and, therefore a stimulus for floaters to stop, investigate and perhaps spend the night. An increase in use at the boiler, as simulated in the 100X subplot, would drastically increase visual impact by eliminating the wild rose, a mitigating influence found beside and hanging directly over the trail. Biological death could be considered complete, and subsequent recovery would be very difficult in Alaska's short growing season.

The tundralike vegetation, as found at the Napoleon site, holds a special attraction for many people. The deep carpet of moss, delicately beautiful lichen, and high incidence of berries would probably result in people wandering in an area such as this, rather than walking purposefully to a destination. This vegetation is found above the river, and is probably less camped on, than a situation as found at the confluence site. However, some floaters have stated a definite preference for

setting up camp on a mossy substrate.

Poor soil, nearness of the permafrost layer, and less exposure to the sun preclude environments like the Napoleon site from purposeful development. Individuals should be discouraged from using such plant communities for camping purposes. The 25O subplot at Napoleon experienced a 92% loss of ground cover (see Table IIa) in a deep and narrow path (see Fig. 13). A matte of brown roots remained, and it was this that accounted for the low figure of only 23% destruction of maximum annual production. Due to this remnant of root matter, it is possible that revegetation at this level of use could restore the trampled subplot, to the state of the controlled plot in one protected growing season. However, continued seasonal use could result in the situation seen in the 100X subplot, i.e., biological damage resulting in essentially no living vegetative matter, not even roots, on the trampled path.

Historically impacted areas, such as the plot on old tailings at Franklin, have a tendency to produce an attitude of: "once disrupted, continue disrupting". Invading species of forbs and willows are numerous and the substrate is poor in topsoil and rich in rocks. Destruction of nonwoody plants was rapid, especially when the ground cover was wet. The willows and other tall species however, were partially effective in hiding the path. At Franklin, decrease in plant production was the most drastic for all of the 250X subplots on the river, but the trail width was one of the narrowest, and the trail depth was so minimal (see Fig. 13) as to be unmeasurable. Judging by surrounding natural trails, continued use at this level would result in a path closely opposed by tall, infringing vegetation, but devoid of plant life on the path itself. Visual impact here would be very low from the ground, air, or the river, and reinvasion of roadlike plant species would be rapid if the trail did not have increased use. However, an area of old tailings could be expected to be visited by more than the overnight floater.

Individuals with a two week, or even a summer at their disposal, would find Franklin a tempting spot to try their luck at panning or dredging (Franklin is a legitimate mining claim and anyone prospecting in the creek may be in trespass). Thus, the estimated two river craft per week and calculated 336 passes per 40 day period may be wholly inadequate. Areas with demonstrated placer deposits can not be considered as merely a stopover spot by recreational floaters. Franklin Creek particularly, with its history, wealth of artifacts, the condition and variety of cabins, and the relative ease in finding a few colors, already has resulted in severe impact to the biology, and the unique physical presence of the town itself. If the plans for improving the trail from Chicken to Franklin are to be implemented, anticipatory measures must be initiated to protect the character of this area from the influx of river and overland visitors.

The confluence's 250X subplot retained a good cover of bruised and browned grass (75% of the sample area still covered). It possessed the

second widest path and exhibited no depression when compared with non-impacted surroundings. Annual production was high, compared to the other subplots at this area, and although the visual impact was obvious, the trail was not barren of plant growth. It was the browned aspect of the path's grass rather than the absence of any vegetation that made the trail distinct. River terraces with moderate evergreen overstory and a river view have traditionally been a favorite of river floaters, and the confluence fits this description well.

The confluence also demonstrated comparatively good resilience. The tent simulation had a good thick matte of yellowed grass, just as the 250X subplot did, and the chances for recovery appeared very good. Not only was this site capable of sustaining a plateau with the current level of trampling, but the type of visitor is also an individual who would only be staying over night, and not the summer. It is important to note here, however, that the subplots with 1000 passes demonstrated very severe damage, with over 92% of the path consisting of pulverized vegetation and dried cracked earth. Both this semideveloped campsite at the confluence, and the concentrated camping area at Franklin suffered for the lack of fire wood. Although the ground cover may be able to withstand the trampling of the current level of use, the stands of hardwood and evergreens are suffering.

Plants from the 4 plots demonstrating the greatest resistance and resilience are listed below, together with those species demonstrating the greatest fragility to trampling:

Fragile Species	Resistant Species
Moss	Yarrow
Lichen	Labrador Tea
Mare's Tail	Bearberry
Forbs	Grasses

Most plants were more susceptible to damage or destruction under wet conditions. Most also showed great recuperative powers after a few days of rain, and then clear and sunny days. Yarrow demonstrated a remarkable invasive ability on the 100X subplots well into July, when damage was already severe to all sections of the subplot. Most subplots exhibited the greatest change due to trampling during the first three visits. Damage increased after this, but at a much more gradual rate. Although damage to the forbs and grasses occurred faster on the old tailings of Franklin, this damage could not become any worse (e.g. trail depth and width) after a certain point, due to the resistant rocky substrate.

Napoleon's moss and lichen, situated on an incline with irregularities, had a slower rate of complete vegetation destruction on the 100X subplot, but new damage did take place right up to the last pass. Roots were broken, soil was dug up, and the irregularities were developing channels from heels sliding down and toes digging in, that could worsen

in the next season's runoff. Such a scenario would further impede natural revegetation.

An ominous indicator obtained from this study was the tremendous jump in visible damage and empirically proven destruction from 250 to the 1000 impacted subplots (see Table I and Figures 8 and 12). It can safely be said that with yearly use, nothing will live; and recovery will be impossible for any section of vegetation along the Fortymile River, that reaches the 1000-passes-per 40-days level (approximately less than one river craft per day at one campsite).

Comments on Research Methods

As mentioned previously, the difficulty with this study is converting the impact on the trampled plots to actual present, and then projected visitor use. This conversion was done by making an educated guess on the numbers of people currently using the river. This value, then, was only an average, while the number of people days at Franklin is so much greater than the people days, the boiler site would experience. Base line demography for the Fortymile River is drastically needed, as well as the continued monitoring of visitor and long-time dweller use.

No attempt was made to hold many of the possible variables constant. The plots were walked from 0800 in the morning to 2200 at night; the footwear varied from tennis shoes to vibram soled boots; up to 20 different people (and weights) were involved in the walking of plots (to the great relief of the researcher); from one to two people may have been walking the 100X subplot simultaneously; and finally, the time variance between trampling visits was from 10 hours to eight days. Such variety was sought, rather than accidental, in an attempt to simulate actual quality of use. Wider areas on the trampled paths were found at the beginning of each subplot, due to turning around or simultaneous walker encounters. These sections were not included in trail depth measurements. Any effect two walkers on the same subplot may have had on the width of the developing trail is an acceptable variable. The busier a trail is, the greater the chance of encountering another hiker, and, thus, the greater the possibility of widening the trail by walking two abreast or passing.

The elimination of variables was sought in measurements for annual production, percent cover, and path width and path depth determinations. To illustrate: parallel 10 cm by 50 cm annual production samples were collected, the same collecting apparatus and methods were employed, the same drying oven and drying times were utilized, and the same balance was used for all samples.

For those wishing to employ the same methodology in determining physical carrying capacity, the following recommendations are suggested:

1) A more reliable control would be one taken adjacent to each subplot. Serious qualifications to any comparison made between a trampled subplot's and a control's annual production, percent cover, and type of plant species, must be made in this study. The variance in these measurements due solely to physical distance apart, and not to trampling impact was significant, and could be eliminated by maintaining a control area within each subplot.

2) Second, when measuring percent cover, different species were often found lying atop one another. Both species were measured and recorded separately in table. It was, therefore, impossible to compare that section of the plot covered with vegetation, to that section barren of vegetation by the figures in Tables IIa,

IIb, and IIc. Such a comparison is of importance within and between study areas. It could be included by measuring both areas covered with vegetation, and also those areas devoid of any plant cover at all.

3) A study like this can not be comsidered complete without a follow-up. The demonstration of one season's trampling gives some idea of what to expect, when an untouched or recovered area is given a controlled quality and quantity of impact. The subsequent recovery, or lack of recovery, of that impacted area is a major concern of a manager hoping to live within the mandate of the Wild and Scenic Act: "... certain selected rivers of the Nation ... shall be preserved in free flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations". (Emphasis added.)

The rate of recovery, type of invading species, or the natural exacerbation of last season's visitor trampling is also knowledge that must be made known for management alternatives to maintain a status quo on a recreational river.

CONCLUSIONS

At the present level of use, trampling in most plant communities on the Fortymile is of minor and often reversible nature. In comparing the communities studied, it was found that areas with good drainage, a concentration of yarrow, wild rose, Labrador Tea, grasses, bearberry and an overstory of young hardwoods and evergreens are more resistant to trampling. Northern exposure, a concentration of moss, lichen, mare's tail, poor drainage, and permafrost near the surface indicate relatively poor resistance. A rocky substrate causes drastic initial destruction of vegetation, but then inhibits any further degregation. Such rocky surfaces often have a concentration of willows that ultimately obscures the path itself. If trampling and average use were the sole determinates of impact, the present policy of minimal regulation on the Fortymile River would suffice. However, high levels of suction dredge use at low water situations, a population at Franklin and Napoleon Creeks that is far from average, heavy use of the confluence campsite, removal of artifacts, gasoline and oil spills from motor craft and dredge operations, and human waste accumulation are characteristics calling for a greater role for management. With the increasing population of Alaska, the continued attraction the State has for those outside, and the massive increase in river recreation, the Bureau should:

1) Continue and increase the collection of baseline biological and sociological data;

2) Obtain further predictive information on the effect increasing floater use will have on biology and visitor perceptions;

3) Begin immediate restorative and hardening policies; and

4) Initiate monitoring of physical and demographic changes from baseline information.

THE CONCEPT OF CARRYING CAPACITY

The original use of carrying capacity related to the number of cattle that could be grazed on a certain acreage of grassland while maintaining adequate feed (Wagar, 1974). For better or worse, the concept has been applied to recreation. An area such as the Fortymile has a certain number of people per season that can make use of the river, and leave it, theoretically, unchanged for the next season's visitors. A magic number (Lime, 1977) of visitor days has been sought by some of those managing a park, river, or wilderness area as a panacea for their problem of worsening impact due to increasing use.

Unfortunately, this magic number, beyond which irreversible damage will occur to the area, and below which a dynamic equilibrium of destruction and recovery occurs, will never materialize. No matter what the level of visitor use to an area, the biology will suffer. It is up to the manager to decide what type of use, and what level of impact he will accept. Then it is up to the life science researcher to define, and then monitor, the reaction of the ecosystem to levels of visitor use, and find a frequency of use corresponding to the manager's concept of allowable impact. A third input, to completely define an area's recreational impact, is necessary. A social scientist should analyze and monitor the attitudes of the visitor (and inhabitant) toward the experience he expects to encounter on the river. Thus the involvement of the manager, the biologist, and the sociologist, as well as the general framework of an area's enabling legislation, must all be considered and weighed before the areas carrying capacity can be defined. The final plan on visitor use and management does not, however, stand unchanging from the initial base line decisions.

A long range plan, in anticipation of increased use, must be formulated to cope with America's increasing demand for outdoor experiences. Carrying capacity can be increased by contingency plans, but there must be figures on how many more people are using an area, what biological changes have occurred since the original field work, if visitor expectations have changed, and what reaction could be expected from the new and old visitor to "hardening" of an area to cope with increased use (Ohmann, 1974). The experience of floating or hiking in the Fortymile will be sought by many with a myriad of interests. The increased use that is predicted can be handled by the river and its surroundings, but this increased use must not cause a reduction in those conditions that originally made the area desirable.

The following section proposes a general outline from which original research, subsequent monitoring, and ultimate management can be applied to maintain the environments integrity, and conserve the types of experience expected by all classifications of visitors. Specific suggestions on Fortymile research, together with current and projected management alternatives to maintain or increase recreational carrying capacity in the last section.

PERTINENT RESEARCH - CARRYING CAPACITY

Outlined below is a framework for initially developing and subsequently adjusting recreational carrying capacity (Stankey, 1974). A uniform chronological order of studies, utilizing comparable techniques, should be employed for all research in carrying capacity, to make possible evaluation and sharing of data, from other river research programs (Bertolino, 1976; Lime, 1977).

Determination of Baselines

Biological

A soils series run on all sections of the resource area (James, 1974).

Identification and location of areas representing sensitive flora and fauna.

Identification of biologically unique areas.

A water quality profile.

Determination of coliform and phosphate concentrations above and below traditional camping areas.

Botanical map indicating dominant plant species.

Inventory of wildlife (include concentration and location).

Camping Areas Existing and Potential (Atchison, 1977; Borden, 1977; Merriam, 1974)

Locate all usable sites for camping.

Note high water levels.

Determine maximum capacity of each.

Evaluate percent of maximum capacity that will not cause unacceptable damage.

Evaluate the campground as to facilities available (Pfister, 1977). e.g. swimming, mining, fishing, climbing, hiking, historical interest, good drinking water, sanitation, firewood

Establish levels of use warranting campsite alterations to protect the site.

Demography

Obtain figures on numbers of visitors at several logically located points in the area.

Determine where individuals enter and leave area.

Determine where camping now occurs and to what intensity.

Determine where, how many, and how long the present visitor stops on hikes or floats.

Determine where and to what extend any special interest activity takes place (e.g. mining).

Visitor Perception

Obtain figures on what visitors expect to experience and what they perceive they experienced (Stankey, 1973).

Determine if this perception is different for different sections of the resource area.

Determine the receptiveness of the current management plan to the expectations of the current visitor.

Determine the population level when congestion becomes a significant negative factor in visitor perception and catalogue when, where, and the type of crowding that occurs.

Miscellaneous

Location of river hazards.

Water level and navigability.

Location and protection of historically interesting sites.

Continuing Research

The accumulation of data to produce a baseline year of impact use, research to protect the type of impact that will occur with a particular increase in visitors, and the continued monitor of baseline information will allow the manager to predict the type of damage that will occur with an increase in use, and allow him to instigate measures to counter-act the increase in ecological and sociological impacts. Management must have the basic information on their area to substantiate

and defend any present plan or future change in managing policy. The procedures below are those which should be undertaken on a continuing basis to keep the managing agency aware of its resource:

Water quality measurements

Changes in campsite ground cover

Wildlife, bird, and fish populations

Visitors days

Visitor attitudes.

MANAGING ALTERNATIVES

As use increases at a recreational area, management plans must neutralize increasing impact. The following is an order of action that could be taken by the managing agency to increase carrying capacity, while retaining most of the positive characteristics of the area (Craig, 1977, Lime, 1971).

Regional coordination of types of experience (solitude vs social) to establish a balance nationwide for all types of outdoor activity.

Dissemination of Information
Information centers located in large metropolitan areas to indicate the type of experience to be expected at a site; variety of facilities; fines for certain behavior; rules concerning garbage, firewood, vehicles, etc; and hints on good floating and camping habits.

Information centers located at entrances and exits of a park and landings of a river.

Rangers on the trail or river to assist and enforce regulations.

Zoning for the separation of conflicting uses (eg. canoe vs motorized river craft). Zoning can be accomplished via separate times for use or via separated locations for use.

Concentration of required facilities at entrances or exits.

Hardening of campsite: "small enclaves of development".

Good original design and site location (Cottrell, 1976).

Tent pads

Paved paths

Walk bridges

Rotation of campsites allowing recovery of heavily impacted areas

Toilets installed with an ascending gradient of efficiency and obtrusiveness

Garbage cans with regular collection

Planting of hardy native species

Watering, fertilizing, reseeding, and mulching of impacted sites

Limit party size, as large groups have a disproportionate impact (Lime, 1972).

Limit number of parties as a last resort. Over 50% of the present rivers in a wilderness area now utilize a permit system incorporating a lottery (Geist, 1976), reservation system or differential fees (Utter, 1976).

Is the Fortymile River worthy of inclusion in our nation's growing system of Scenic and Wild Rivers? The opportunity to observe the wildlife, relive a stirring chapter in Alaska'a gold rush history, view current recreational mining activities, extract a moderate amount of gold, negotiate a number of intermediate class rapids, and float the Yukon are worthy qualifications, even if the growing demand for river recreation did not necessitate more protected river systems. However, a unique environment comes with unique problems. Small suction dredge owners and larger operations, using cats and hydraulic methods to extract Fortymile gold, have all expressed concern about the effective elimination of mining from a river producing "good" quantities of ore. The probable cessation of large scale mining by severely restrictive regulations may not be warranted in consideration of the commercial demand for gold, enduring evidence of large scale mining operations in the past, and the elimination of a way of life for numerous individuals, e.g., mining, as well as homesteading and trapping on the river. The number and location of other rivers offering characteristics defined by the Wild and Scenic Act of 1968 must be evaluated for the state of Alaska. Any nationwide decision on recreational lands must be contingent on the concentration of possible recreational users vs. potential alternative rivers. The feeling expressed by many Alaskans that their state is being made into a park for the lower forty-eight, is a case in point. It is the belief here, however, that the Fortymile River be designated a Wild and Scenic River and immediate, but unobtrusive, steps be taken to stabilize and even restore particular sections of the river currently receiving severe impact. The following comments are arranged in a recommended sequence of implimentation based on extrapolation from the research described earlier in this report, personal familiarization with use, condition of the South Fork and the Fortymile itself, and attention to comments made by river users.

More information on how to treat the out-of-doors, and regulations pertinent to the Fortymile should be conspicuously available, and even made required reading at all canoe landings.

The current status of the Franklin camping area is serious due to congestion, lack of firewood, and no proper receptacle for human wastes. Permission to place a primitive toilet at Franklin should be asked of those owning the Franklin claim. It is this type of information, location of primitive facilities, that should be included in the literature found at the landings, and available in Alaska's major cities. As yet, only this verbal prompting towards concentrated campsites (Franklin and the confluence) should be utilized.

Social profiles of visitor and inhabitants of the Fortymile should be obtained next summer. This could be done by those people living full-time on the river, providing both needed data for BLM management, and

positive public relations.

Strong suggestions of floaters that backpacking-like stoves (cartridge or white gas) be used, rather than cutting firewood, is strongly recommended.

Nesting areas for the Peregrine Falcon and Golden Eagle, noted during this summers field work, should be eliminated from any campground consideration.

Studies on water quality and the other biological parameters mentioned in the preceeding section, should be initiated soon to produce that baseline data so important for future river decisions.

A complete campground inventory, with concentration on sandy beach sites, rather than heavily vegetated sites, should be done in the near future. First priority for this inventory should be the South Fork and the Fortymile River. A campsite inventory of the less heavily visited North and Middle Forks can be done at a later date.

The hiring and training of one or more river rangers should be undertaken to retard artifact removal, halt unnecessary wood cutting, and act as a further source of information for decreasing improper river practices. Such an individual could also do much of the sociological and biological monitering of baseline data accumulated before he was hired.

To further reduce visitor camping impact on embankment vegetation, and to maintain components of early Fortymile history, restoration and maintenance of cabins should be initiated, and then made available to floaters. A time limit for each visit, and ultimately a reservation system may be necessary for such accomodations.

Current use of the river and realistic projections do not warrant any visitor regulation other than giving floaters the best possible information on good camping habits, and directing them to Franklin and the confluence. These two areas are receiving the most visitor impact at this time. They are deserving of consideration as to waste disposal, initial hardening of the campground sites, their maintenance, and enforcement of firewood cutting.

As rumors of, and actual strikes of placer deposits are made, large temporary accumulations of suction dredge operators occur. Temporary measures affecting cabin use, wood cutting, excessive noise, water and air quality degragation, and waste disposal should be undertaken. Along with other long-term camping effects, gas spills, dead dogs in the river, and cabin destruction have been noted during those small gold strikes.

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APPENDIX I

FIELD LOG: Summer 1977
The Fortymile River: Biological Aspects of Carrying Capacity

Trip #1
June 22 night at Franklin
June 23 out at O'Brien
Orientation float
No technical photos

Trip #2
June 27 night at Franklin
June 28 out at O'Brien Creek
Photos of Napoleon, Franklin and Confluence set up

Trip #3
June 29 night at Franklin
June 30 night on bar at Sq. #23
July 1 out
Boiler set up and first walk for all plots
Black and white photos

Trip #4
July 3 night at Chicken
July 4 night at Franklin
July 5 night at Confluence
July 6 out
Second walk for all plots
Color print of 100X Franklin plot
No photos of Napoleon, Confluence, or Boiler

Trip #5
July 7 night at Boiler
July 8 out
Third walk for all plots
Color print of Franklin 100X only
No photos of any other plots

Trip #6
July 13 night at Chicken
July 14 night at Confluence
July 15 night at Long Bar
July 16 out
Fourth walk for all plots
Pre and post for all plots, as well as controls, fire and water marks

Trip #7
July 18 night at Walker Fork
July 19 night at Franklin
July 20 night at Long Bar
July 21 out
Fifth walk
Photos pre and post and campsites for all sites

FIELD LOG: Continued

Trip #8 July 22 night at Confluence
July 23 night at Boiler
July 24 out
Sixth walk for all sites
Seventh walk for Confluence and Boiler
River rising and fast
Post photos of all plots

Trip #9 July 26 night at Napoleon
July 27 night at Franklin
Seventh walk for Napoleon and Franklin
Eighth walk for all sites
Pre, post and control for all plots and walks - photos
July 28 night at Bonanza Bar
July 29 night at Bruin Creek
July 30 night at Fortymile site
July 31 night at Eagle Roadhouse

Trip #10 August 3 night at Napoleon
August 4 night at Franklin
August 5 night at Confluence
August 6 night at Boiler
Walk all plots ninth and tenth times
Pictures pre, post, control, overall, techniques, etc.
August 7 night at Chicken

APPENDIX II

Common and Scientific Names of Flora Found on the Study Plots

Achillea millefolium
Yarrow, Millfoil

Arctostaphylos uva-ursi
Bearberry, Kinnikinnick, Hog Cranberry

Cerastium sp.
The Mouse Eared chickweeds

Cladonia sp.
The Lichens

Epilobium angustifolium
Fireweed, Great Willow-herb

Elymus sp.
The Grasses

Ercophorum sp.
The Sedges

Eriophorum vaginatum
Cottongrass tussocks

Hedysarum mackenzii
Wiid Sweet Pea, McKenzie's Hedysarum

Haloragidaceae vulgaris
Mare's Tail

Lupinus arcticus
Arctic Lupine

Ledum groenlandicum
Labrador Tea

Mertinensia paniculata
Tall Lungwort, Blue Bells, Chiming Bells

Papaver radicatum
Arctic Poppy, Iceland Poppy

Rosa acicularis
Prickly Rose, Wild Rose

Sphagnum sp.
The Mosses

Vaccinium uliginosum
Bog or Common Blueberry, Bilberry

Betula paperifera
Paper Birch

Picea mariana
Black Spruce

Picea glauca
White Spruce

Populus balsanifera
Balsam Poplar

Populrs tremadoides
Quaking Aspen

Salix sp.
The Willows

BIBLIOGRAPHY

Atchinson, Stewart W., Steven W. Carothers, and R. Roy Johnson, 1977. Some Ecological Considerations Associated with River Recreation Management, pp. 222 - 225. In Proceedings: River Recreation Management and Research Symposium (hereafter referred to as Proc., River Recreation). USDA Ser. Gen. Tech. Rep. NC-28. North Central For. Exp. Stn., St. Paul, Minnesota.

Bell, Katherine L., and Lawrence C. Bliss, 1973. Alpine Disturbance Studies: Olympic National Park, USA. Biological Conservation 5(1):25 - 32.

Bell, Wendell G. 1977. Historical Resources of the Fortymile River, Alaska. M.S. Thesis. Texas Tech. University. 101 pp.

Bertolino, Bart. 1976. Recreation Site Carrying Capacity Hoozier National Forest. In Managing Recreation Resources for Century III. pp. 77 - 80 Proc., John S. Wright Forestry Conf., Pardue Univ., Dept. Forestry and Natural Resources, West Lafayette, Indiana.

Borden, F. Yates; Brian J. Turner, and Charles H. Strauss, 1977. Colorado River Campsite Inventory, pp. 226 - 231. In: Proc.; River Recreation, USDA For. Ser. Gen. Tech. Rep. NC-28. North Central For. Exp. Stn., St. Paul, Minnesota.

Christensen, Rex L. 1975. Alternate Method for Herberium Mounts. Technical Note 258. USDI Bureau of Land Management. Denver Service Center, Denver, Colorado.

Cottrell, Richard L. 1976. Site Design for the Future: Lessons from the Past, pp. 62 - 68. In: Managing Recreation Resources for Century III. Proc., John S. Wright Forestry Conf., Purdue Univ., Dept. of Forestry and Natural Resources, West Lafayette, Indiana.

Craig, William S. 1977. Reducing Impacts from River Recreation Users, pp. 155 - 162. In: Proc., River Recreation, USDA For. Ser. Gen. Tech. Rep. NC-28. North Central For. Exp. Stn., St. Paul, Minnesota.

Dale, D., and T. Weaver. 1974. Trampling Effects on Vegetation of the Trail Corridors of North Rocky Mountain Forests. J. Applied Ecology II: 767 - 772.

Godfrey, E. Bruce, and Robert L. Peckfelder, 1972. Recreation Carrying Capacity and Wild Rivers: A Case Study of the Middle Fork of the Salmon, pp. 353 - 360. Paper presented at the Western Agr. Econ. Assoc. Meeting, Logan, Utah.

Geist, David A. 1976. The Carrying Capacity of Public Wild Land Recreation Areas: Evaluation of Alternative Measures. J. Leisure Research 8(2): 123 - 128.

Held, R. Burnell, Stanley Brickler, and Arthur P. Wilcox, 1969. A Study to Develop Criteria for Determining the Carrying Capacity of Areas Within the National Park System. Final Rep.: Contract Between USDI, National Park Service and the Center for Research and Education, Estes Park, Colorado.

Heller, Christine, 1964. Wild Flowers of Alaska. Heller Enterprises, Anchorage, Alaska. 104 pp.

James, George A 1974. Physical Site Management. USDA For. Ser. Tech. Bull. Rep. 7, North Central For. Exp. St., St. Paul, Minnesota.

Lime, David W. 1971. Factors Influencing Campground Use in the Superior National Forest of Minnesota. USDA For. Ser. Res. Pap. NC-60, 18 pp. North Central For. Exp. Stn., St. Paul, Minnesota.

Lime, David W. 1972. Large Groups in the Boundary Waters Canoe Area-Their Numbers, Characteristics, and Impact. USDA For. Ser. Res. Note NC-142, 4 pp. North Central For. Exp. Stn., St. Paul, Minnesota.

Lime, David W. 1976. Limited Knowledge of Recreation Use and Use-Management of Backcountry River Resources. Portion of Line Project No. FS-NC-1951. USDA For. Ser. North Central For. Stn., St. Paul, Minnesota.

Lime, David W. 1977. The Magic Number: Does it Exist? pp. 26 - 28. In: Proc., The Lake Superior Visitor: Profit or Loss?, Sigurd Olson Institute, Northland College, Ashland, Wisconsin.

Lime, David W., and George H. Stankey, 1971. Carrying Capacity: Maintaining Outdoor Recreation Quality, pp. 174 - 184. In: Forest Recreation Symp. Proc., October 12-14, New York State Univ., Coll. For., Syracuse, New York.

McCool, Stephen F., Lawrence E. Roger, and James J. Kennedy, 1974. Recreational Use and Management Problems on Utah's Wild Rivers, Proc., Utah Academy of Sciences, Arts, and Letters. 51(1): 109-115.

Marnell, Leo F. 1976 Applying Recreation Carrying Capacity Concepts. pp. 69-73. In: Managing Recreation Resources for Century III. Proc., John S. Wright Forestry Conf., Purdue Univ., Dept. Forestry and Natural Resources, West Lafayette, Indiana.

Merriam, Jr., L. C., and C. K. Smith, 1974. Visitor Impact on Newly Developed Campsites in the Boundary Waters Canoe Area. J. Forestry 72(10): 627 - 630

Ohmann, Lewis F. 1974. Ecological Carrying Capacity, pp. 24 - 28. USDA For. Ser. Gen. Tech. Report NC-9. North Central For. Exp. Stn. St. Paul, Minnesota.

Pfister, Robert E., and Robert E. Frankel, 1975. The Concept of Carrying Capacity: Its Application for Management of Oregon's Scenic Waterway System. 50 pp. Rogue River Study - Report 2. Water Resources Research Institute, Oregon State Univ., and the Oregon State Marine Board, Corvallis, Oregon.

Pfister, Robert E. 1977. Campsite Choice Behavior in the River Setting: A Pilot Study on the Rogue River, Oregon. pp. 351 - 358. In: Proc., River Recreation. USDA For. Ser. Gen. Tech. Rep. NC-28. North Central For. Exp. Stn., St. Paul, Minnesota.

Price, Fred 1925. Mining is Now Moving Along on the Yukon. Alaska Weekly. 17 July:4

Potter, Louise. 1969. Roadside Flowers of Alaska. Roger Burt Co., Hanover, N.H. 527 pp.

Robbins, C.S., Bruun, B., H.S. Zim, and A. Singer, 1966. Birds of North America. Golden Press Co., New York. 340 pp.

Speight, Martin C.D. 1973. Outdoor Recreation and Its Ecological Effects. Discussion Papers in Conservation. Dept. of Botany, Westfield College, University of London, London, England.

Stankey, George H. 1972. A Strategy for the Definition and Management of Wilderness Quality. P. 88 in John V. Krutilla, ed. Natural Environments: Studies in Theoretical and Applied Analysis. The John Hopkins University Press, Baltimore, Md.

Stankey, George H. 1973. Visitor Perception of Wilderness Recreation Carrying Capacity. USDA For. Ser. Gen. Tech. Rep. INT142, 21 pp. Intermountain For. and Range Exp. Stn., Ogden, Utah.

Stankey, George H. 1974. Criteria for the Determination of Recreational Carrying Capacity in the Colorado River Basin. Pages 83 - 101 in A Berry Crawford and Dean F. Peterson, eds. Environmental Management in the Colorado River Basin. Utah State University Press, Logan, Utah.

Stankey, George H., and Lime, David W. 1973. Recreational Carrying Capacity: An Annotated Bibliography. USDA For. Ser. Gen. Tech. Rep. INT-3, 45 pp. Intermountain For. and Range Exp. St., Ogden, Utah.

Sudia, Theodore W., and James M. Simpson. 1973. Recreational Carrying Capacity of the National Parks. Guidelines 3(3).

U.S. Department of Interior, Alaska Planning Group. 1973. Final Environ,ental Impact Statement, Fortymile National Wild and Scenic River.

Utter, Jack G. 1976. Wilderness and Wild River Carrying Capacity Management: A Proposed Case Study of Use Permit Allocation on the Middle Fork of the Salmon River. News Review Publishing Co., Moscow, Idaho.

Verburg, K. N.D. The Carrying Capacity of Recreational Lands: A Review. Parks Canada, Planning, Prairie Regional Office.

Vierick, Leslie A., and Elbert L. Little, Jr. 1972. Alaska Trees and Shrubs. USDA For. Ser. Agr. Handbook #410. U.S. Government Printing Office, Washington, D.C.

Wagar, J. Alan, 1964. The Carrying Capacity of Wildlands for Recreation. For. Sci. Monog. 7:23 p.

Wagar, J. Alan, 1974. Recreational Carrying Capacity Reconsidered J. Forestry 74(5):274 - 278.

Wagar, J. Alan, 1977. Recreational Carrying Capacity. Paper prepared for Wildland Recreation Conference, Feb. 28-March 3, Banff, Canada.

Weaver, T., and Dale, D. 1977. Trampling Effects of Hikers, Motorcycles or Horses in Meadows and Forests. J. Applied Ecology (Feb.), In Print.

Willard, Beatrice E., and John W. Marr. 1970. Effects of Human Activities on Alpine Tundra Ecosystems in Rocky Mountain National Park, Colorado. Biological Conservation 2(4):257-265.

Willard, Beatrice E., and John W. Marr. 1971. Recovery of Alpine Tundra Under Protection After Damage by Human Activities in the Rocky Mountains of Colorado. Biological Conservation 3(3): 181-190.

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The purpose of the internship program is to bring organizations involved in community and economic development, environmental problems and their students in the West for the benefit of all.

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